and robust design.

[0022] FIG. 3 is a representative graph of image quality (mean and variance) as a function of cost as determined by the statistical design in accordance with the preferred embodiment of the invention.

[0023] FIG. 4 is a block diagram showing a computer system for statistical design of a probe and an imager in accordance with the preferred embodiment of the invention.

[0024] FIG. 5 is a schematic depicting a window of the Transducer Design Advisor for specifying input parameters to an acoustic stack model in accordance with the preferred embodiment of the invention.

[0025] FIG. 6 is a schematic depicting a window of the Transducer Design Advisor for selecting which probe multi-row technology should be simulated in accordance with the preferred embodiment of the invention.

[0026] FIG. 7 is a flowchart showing the program flow for the Transducer Design Advisor in accordance with the preferred embodiment of the invention.

[0027] FIG. 8 is a schematic depicting a Layer Properties window of the Transducer Design Advisor which appears, in accordance with the preferred embodiment, when the user clicks on the rectangle for front layer 1 on the window shown in FIG. 3.

[0028] FIG. 9 is a diagram showing class decomposition of a typical window of the Transducer Design Advisor having an animated graphical display which is sensitive to mouse events in accordance with the preferred embodiment of the invention.

[0029] FIG. 10 is a diagram showing the class decomposition of the classes that implement the window navigation strategy of the Transducer

Design Advisor in accordance with the preferred embodiment of the invention.

[0030] FIG. 11 is a schematic depicting a window of the Transducer Design Advisor for implementing a "policy" in accordance with the preferred embodiment of the invention. This policy specification is a list of the importance of each CTQ as a function of range. The meaning of the term "policy" will be defined in more detail below.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0031] The first stage of the design method in accordance with the preferred embodiment of the invention comprises several computational blocks, several databases, and an image quality specification (typically generated by Systems Engineering).

[0032] Block 10 in FIG. 1 represents the Transducer Design Advisor (TDA) for guiding creation of a parameter set in accordance with the preferred embodiment. The Transducer Design Advisor is used to specify some of the characteristics of a probe, including material properties retrieved from a material properties database 2. The material properties data in database 2 includes, but is not limited to, the properties of those materials suited to piezoelectric energy conversion, acoustic impedance matching, backing and focusing of acoustic beams. Further, the Transducer Design Advisor allows the designer to select which of the controllable parameters will be varied, and which are held constant during the various simulation runs. These controllable parameters, which are DOE variables, will be referred to as "*x*'s" (item 12 in FIG. 1). The Transducer Design Advisor also guides the selection of a suitable phantom for the simulation (item 14 in FIG. 1).

[0033] In accordance with the preferred embodiment of the invention, the *x*'s and accompanying fixed parameters are presented to the acoustic stack simulator 16, which computes an impulse response for the current probe specification. Preferably, the acoustic stack simulator is of the type described by Selfridge and Gehlbach in "KLM Transducer Model

Implementation Using Transfer Matrices," Proc. IEEE Ultrasonics Symposium, San Francisco (1985)], or is a finite element model.

[0034] The impulse response from the acoustic stack simulator, together with the phantom and imager parameters, forms the input to the ultrasound beam simulator 18. Some of the imager parameters are defined in the Transducer Design Advisor 10; some are varied during the DOE runs, while others are copied from the values for similar imaging situations, which are available in the database 4 of previously optimized probes. Dividing the parameters in this fashion is necessary because the total set of x's usually exceeds 1000. A practical number of x's is less than 20, if the simulation is run on a single processor system of low cost. The imager parameter database 4 contains data such as the apodization functions, focusing schedule and F-numbers for a given probe.

[0035] Preferably, the ultrasound beam simulator 18 computes acoustic diffraction given an impulse response and a definition of the aperture geometry. The preferred ultrasound beam simulator is based on the FIELD II program [see Jørgen Arendt Jensen and Peter Munk, Computer Phantoms for Simulating Ultrasound B-Mode and CFM Images," 23rd Acoustical Imaging Symposium, Boston, Massachusetts, April 13-16 (1997)]. A finite element code may also be used for the beam simulator, in order to simulate nonlinear sound propagation and scattering. The beam simulator output can be displayed as an image 20.

[0036] The method in accordance with the preferred embodiment further comprises a "scoring" package 22 that quantifies the diagnostic value of the image simulated. The inputs to the process are an image quality specification 6 and the parameters chosen via the Transducer Design Advisor for optimization. The image quality specification 6 may include the following: detail resolution requirements; contrast resolution requirements; measures of the variance of the detail and contrast resolutions over the range of interest in the image; sidelobe level requirements; measures of the importance of a